Atlantic Salmon Potential of the Mushamush River, Lunenburg County, Nova Scotia

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CONTENTS

LIST OF TABLES. iii

LIST OF ILLUSTRATIONS v

ABSTRACT/RÉSUMÉ vii

INTRODUCTION. 1

METHODS 1

RESULTS AND DISCUSSION. 1

REFERENCES. 7

ACKNOWLEDGEMENTS. 7

LIST OF TABLES

TABLE 1. Temperature, flow rate, pH and alkalinity measurements for the four study rivers during 1982 2

TABLE 2. Angler effort on the Gold, Ingram and Petite rivers, 1955-79. 5

TABLE 3. Some chemical characteristics of selected sites on the Mushamush River system during 1982 6

LIST OF ILLUSTRATIONS

FIG. 1. Location of drainage areas of the study rivers. viii

FIG. 2. Relationship between mean flow rates during the 31 May-4 Nov period and drainage areas for the Petite, Mushamush, Gold and Ingram rivers. 2

FIG. 3. Map of the Mushamush River showing the electrofishing sites and the sites where water was collected for chemical analysis 2

FIG. 4. Comparison between precipitation amounts during the study months and mean precipitation amounts during the same months for the 1961-80 period at the Bridgewater Climatological Station. 3

FIG. 5. Relationship between flow rate and pH of the Petite, Mushamush, Gold and Ingram rivers during 1982. 3

FIG. 6. Relationship between drainage area and angling catch during the years 1955-59 for the Gold, Petite, Ingram and Mushamush rivers . . 4

FIG. 7. Numbers of salmon angled per 5-year period on the study rivers during the 1955-79 interval. 4

ABSTRACT

MacPhail, D.K., E.J. McLean and G.J. Farmer. 1983. Atlantic salmon potential of the Mushamush River, Lunenburg County, Nova Scotia. Can. MS Rep. Fish. Aquat. Sci. No. 1719. viii + 7 p.

Flow rates and various water chemistry characteristics were monitored during a seven-month period for the Petite, Mushamush, Gold and Ingram rivers, located on the south shore of Nova Scotia. This information, coupled with salmon angling catch and effort statistics for these systems and stream and lake survey data, was used to determine requirements for Atlantic salmon enhancement.

Key words: Mushamush River, Petite Rivière, Gold River, Ingram River, Atlantic salmon potential, flow rates, water temperature, water chemistry, angling catch and effort, salmon enhancement.

RÉSUMÉ

MacPhail, D.K., E.J. McLean and G.J. Farmer. 1983. Atlantic salmon potential of the Mushamush River, Lunenburg County, Nova Scotia. Can. MS Rep. Fish. Aquat. Sci. No. 1719. viii + 7 p.

Le débit et les diverses caractéristiques chimiques de l'eau des rivières Petite, Mushamush, Gold et Ingram, dans le secteur sud de la Nouvelle-Écosse, ont été suivis pendant une période de sept mois. Ces données, couplées aux statistiques de prises sportives et d'effort de pêche du saumon dans ces réseaux, ainsi que celles recueillies lors de relevés de cours d'eau et de lacs ont servi à déterminer les conditions de la revalorisation du saumon atlantique.

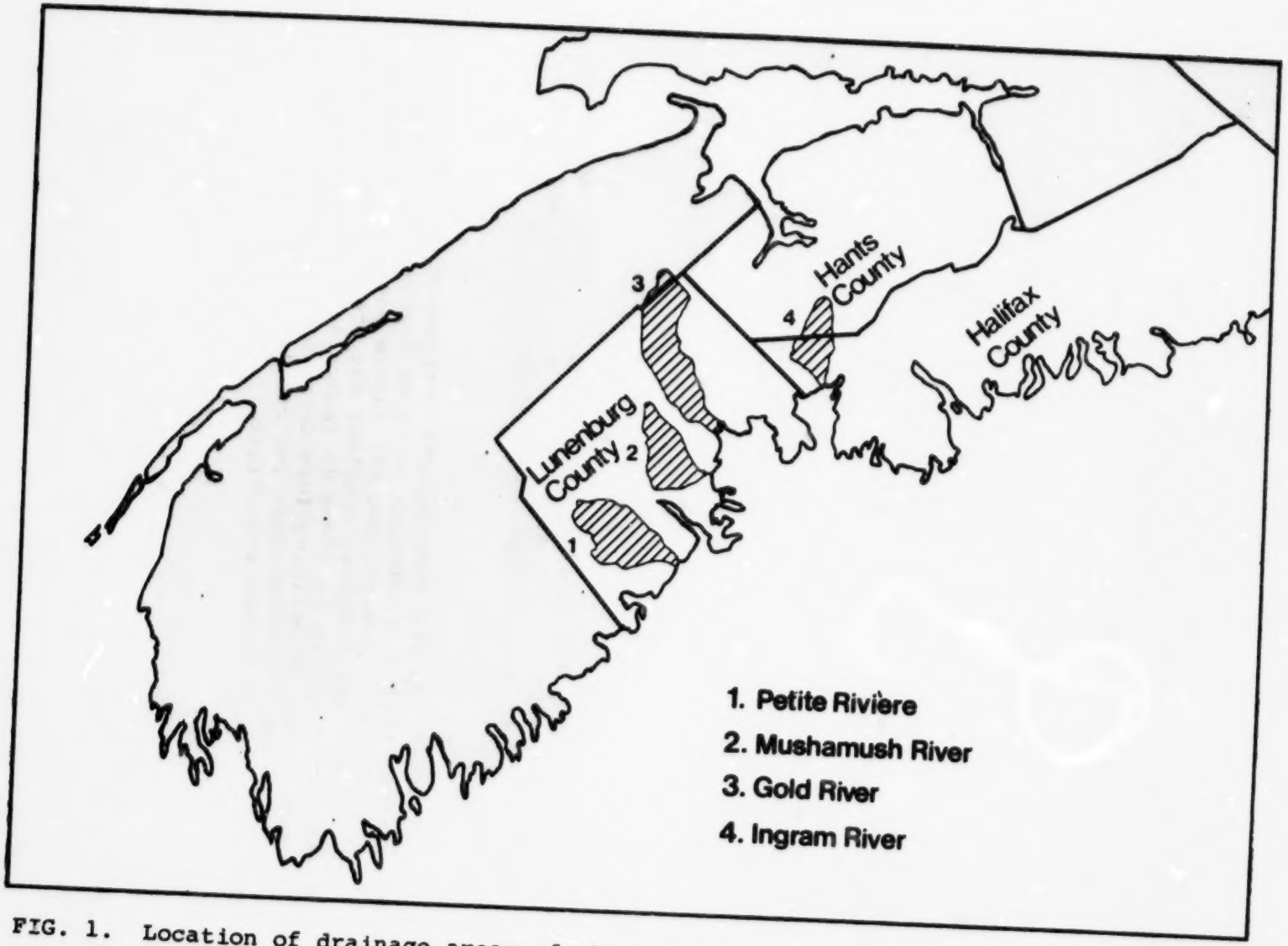

FIG. 1. Location of drainage areas of the study rivers.

INTRODUCTION

Four relatively small Atlantic salmon rivers (mean annual flow ≤ 11 m^3/second) located on the south shore of Nova Scotia (Fig. 1) have recently been considered as sites for enhancement projects utilizing hatchery-produced Atlantic salmon. Three of these rivers (Petite, Mushamush and Gold) are located in Lunenburg County and the other (Ingram) is nearby in Halifax County. Small numbers of hatchery-reared juvenile salmon of LaHave River stock were released in three of these rivers during 1982. The Petite and the Ingram rivers received 4,500 and 14,820 smolts respectively during May, 1982, and the Mushamush River received 14,572 underyearling parr during November, 1982. Salmon naturally produced in the Gold River have continued to support an angling fishery which has averaged 125 fish annually during the past 25 years.

The Mushamush River is of particular interest for salmon enhancement because barriers to fish passage which existed on this river have been removed during the past decade. Seven barriers were in place during 1955 and only two salmon were captured that year at a fence situated at the head of tide (MacEachern 1955). Department of Fisheries and Oceans angling records show that only one salmon was captured during the 1951-79 period (Smith 1981). Electrofishing surveys conducted during 1982 have indicated that the river has been recolonized by naturally produced Atlantic salmon, as low densities of juveniles were observed in most areas of the system.

METHODS

To better assess the potential of these four rivers for continued salmon enhancement activities, flow rate, water temperature, pH and total alkalinity were measured at regular intervals during an approximate five-month period (31 May-4 Nov) in 1982. These measurements were taken at the first suitable site above the head of tide. Difficulty was sometimes encountered in finding a suitable site on each river for flow measurement due to water levels which were either too high or low, and because of both man-made and natural objects which divided the rivers into several channels. Thus, the first suitable point above tide on the Petite Rivière was found to be at its confluence with Brown Branch Brook. Flows at this location were calculated separately for each branch and then added to provide a flow estimate for the system.

For each river site, an Ott current metre (Model C-1) was used to measure velocity at three equally spaced positions on a line delineating the width of the river. The propeller of the metre was adjusted at each position so that measurements were made at 0.6 of total depth. Flow rate was then estimated from the equation: $R = W \cdot D \cdot V$ where:

R = flow rate or volume
W = river width
D = river depth (average of 3 measurements)
V = water velocity (average of 3 measurements)

Water samples were collected at each site in polyethylene containers and transported to the laboratory for analysis of pH and total alkalinity. Because of the particular interest in the Mushamush River, seven sites were selected for a more complete analysis, which included measurements of pH, total alkalinity, total hardness, specific conductance, apparent color, chloride, calcium, magnesium and aluminum. Measurements of pH were made with a Metrohm Herisau pH meter (Model E588). Total hardness, total alkalinity, chloride and sulfate were determined by using techniques from Traversy (1971): hardness, by EDTA titration to Eriochrome Black T color change; alkalinity by potentiometric titration to pH end points of 4.5 and 4.2, with standard H_2SO_4; chloride by the automated thiocyanate method; and sulfate, by the titrimetric method, with thorin indicator. Specific conductance was measured in the laboratory at 25°C with a Metrohm Herisau conductivity meter and apparent color with a Helige Aqua Tester. Samples for the analysis of metals were preserved in the field with 1 ml of concentrated HNO_3 per 500 ml of sample and later analysed in the laboratory with a Perkin-Elmer atomic- absorption spectrophotometer (Anon. 1973).

RESULTS AND DISCUSSION

Measurements of water temperatures (Table 1) suggest that the Petite and Mushamush rivers warm at a slower rate in the spring and cool more slowly during the fall than the Gold and Ingram rivers, which may be a consequence of the larger lakes on the former two systems. Mean flow rates during the 5-month period were 2.4 m^3/s for the Gold and Petite rivers, 1.5 m^3/s for the Mushamush River and 1.2 m^3/s for the Ingram River (Table 1 and Fig. 2) reflecting the larger drainage areas of the Gold and Petite systems (Fig. 1). Although flows recorded during the 4 Aug-4 Nov period were lowest in the Mushamush River, flow rates during the 31 May-28 Jun period were about 3 m^3/s and comparable to those in the Petite and Gold rivers (1.7-5.1 m^3/s), suggesting that early-run salmon can gain access to headwater lakes of the Mushamush system (Fig. 3) for holding during the summer months. The four headwater lakes have a total area of 2,000 hectares; Caribou Lake is one of the deeper lakes in Nova Scotia, having mean and maximum depths of 20 m and 50 m, respectively (Nova Scotia Dept. of Lands and Forests Survey, unpublished data).

Precipitation amounts recorded during the months of May-October, 1982, at the Bridgewater Climatological Station, located within the study area, are compared with

TABLE 1. Temperature, flow rate, pH and alkalinity measurements for the four study rivers during 1982.

River	Drainage area (km^2)	Date	Temperature (°C)	Flow rate (m^3/second)	pH	Total alkalinity (mg/L)
Gold	370.0	May 31	19.0	1.7	5.7	<0.5
		Jun 28	21.0	4.5	5.4	<0.5
		Aug 4	18.5	2.3	5.8	0.5
		Aug 30	19.0	1.1	6.0	0.6
		Sep 29	18.0	2.7	5.7	1.1
		Nov 4	13.0	2.1	6.1	1.1
Ingram	114.7	May 31	18.0	1.4	5.2	<0.5
		Jun 28	20.0	1.3	5.1	<0.5
		Aug 4	22.0	1.5	5.1	<0.5
		Aug 30	16.0	1.0	5.2	<0.5
		Sep 29	17.5	1.3	5.0	<0.5
		Nov 4	12.0	0.9	5.5	<0.5
Petite Rivière	229.0	May 31	14.2	5.1	5.7	<0.5
		Jun 28	21.0	4.1	5.5	<0.5
		Aug 4	19.2	1.7	5.4	<0.5
		Aug 30	17.5	0.9	5.8	0.6
		Sep 29	16.2	1.4	5.4	<0.5
		Nov 4	13.5	1.4	6.0	<0.5
Mushamush	157.5	May 31	15.5	3.0	6.3	1.9
		Jun 28	22.0	3.1	6.4	1.7
		Aug 4	21.0	0.9	6.5	2.1
		Aug 30	18.8	0.6	6.5	2.8
		Sep 29	17.2	0.9	6.6	3.4
		Nov 4	14.5	0.6	6.6	3.7

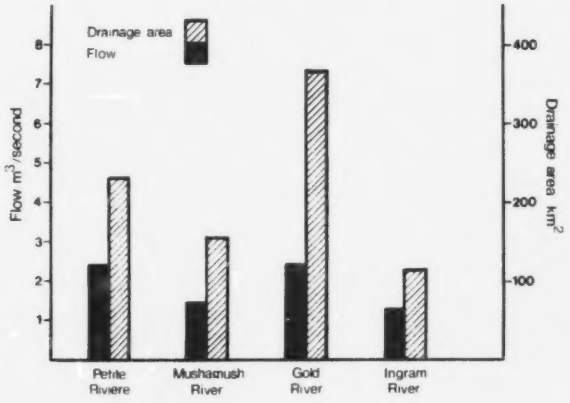

FIG. 2. Relationship between mean flow rates during the 31 May-4 Nov period and drainage areas for the Petite, Mushamush, Gold and Ingram rivers.

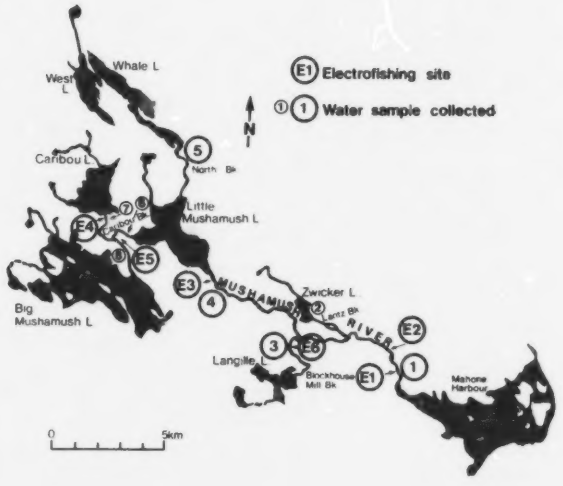

FIG. 3. Map of the Musamush River showing the electrofishing sites and the sites where water was collected for chemical analysis.

mean precipitation amounts during the same months for the 1961-80 period (Fig. 4). For all months except June and September, precipitation amounts during 1982 were substantially lower than the mean amounts recorded during the 20-year period, which explains the relatively low flows recorded in these rivers during 1982.

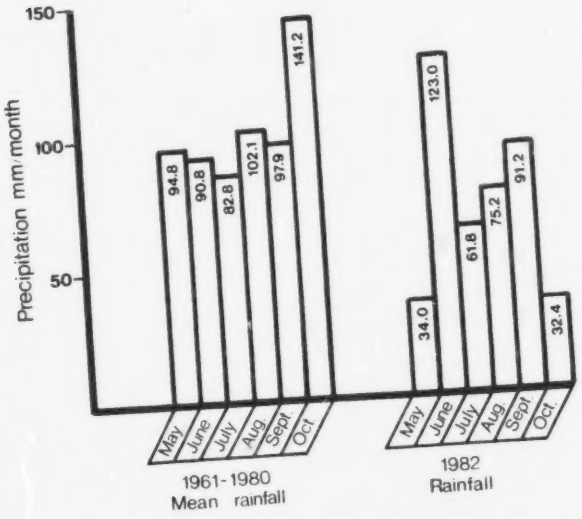

FIG. 4. Comparison between precipitation amounts during the study months and mean precipitation amounts during the same months for the 1961-80 period at the Bridgewater Climatological Station.

Watt et al. (1983) have demonstrated seasonal trends in the pH of some Nova Scotia rivers, with minimum pH occurring during mid-winter, followed by a continuous rise until late summer and then an abrupt decline to low winter values. Although maximum annual pH in September coincides with the period of minimum annual flow, the minimum pH in mid-winter precedes maximum flows by a month or more. Accordingly, the pH measurements of the Gold, Petite and Ingram rivers were found to be inversely correlated with flow rates (Fig. 5). Thus pH was lowest during the initial months (May and June) of sampling and increased during the summer and fall as flows decreased.

Mean annual pH of precipitation in Nova Scotia ranges from 4.4 to 4.6 (Kerekes 1980; Farmer et al. 1980; Watt et al. 1983), and precipitation is generally more acidic during the spring and summer than during the late fall and winter (Farmer et al. 1980). The greater amounts of precipitation which normally occur during the fall may cause river pH to begin to decline at that time, while the relatively high pH of winter precipitation, especially snow, explains the pH rise which occurs during spring runoff. During summer months when surface runoff and stream flows are usually minimal, both groundwater of higher pH (which comprises a greater proportion of stream flow at that time) and the photosynthetic activity of aquatic plants (which produce alkalinity) combine to increase river pH. These factors probably account for the pH changes observed in three of the study rivers. The pH of the Mushamush River remained more constant at all flow rates and reflects the system's relatively high alkalinity which effectively buffers against acid inputs.

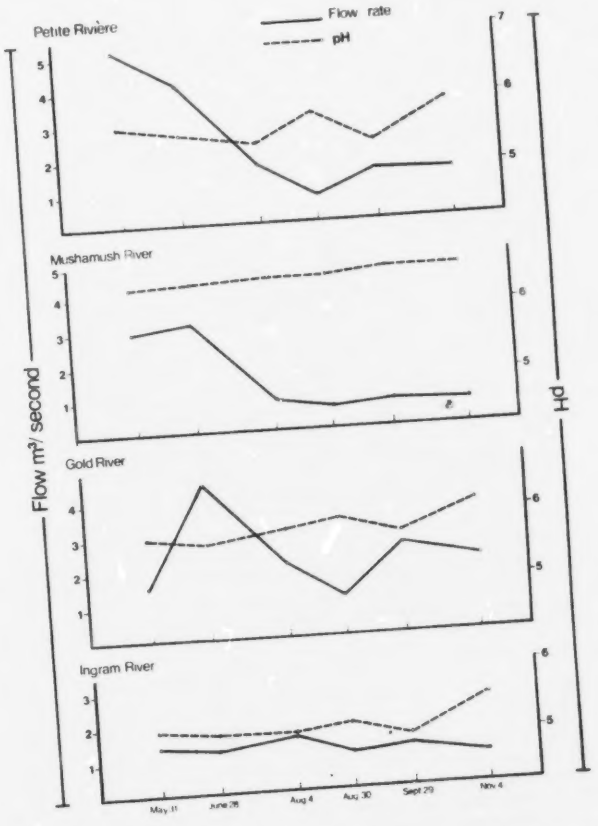

FIG. 5. Relationship between flow rate and pH of the Petite, Mushamush, Gold and Ingram rivers during 1982.

During the 31 May-4 Nov, 1982, period, pH values were highest in the Mushamush River (6.3-6.6) and lowest in the Ingram River (5.0-5.5), while values in both the Petite and Gold rivers were similar and intermediate (5.4-6.1) (Table 1). Watt et al. (1983) measured mean pH values during the 1980-81 period of 5.6 for the Petite, 5.5 for the Gold and 5.0 for the Ingram River. Total alkalinity was greatest in

the Mushamush River (1.7-3.7 mg/L) and lowest in the Ingram River (all measurements < 0.5 mg/L). Alkalinity was detectable in the Petite Rivière only on the 30 Aug sampling date, when the lowest flow rate was recorded. Alkalinity for the Gold River ranged from 0.5 to 1.1 mg/L during the 4 Aug-4 Nov period, but was not detectable (using techniques previously described) during May and June.

Watt et al. (1983) have shown that the pH of rivers in Nova Scotia is closely related to geology, and in the geologically sensitive areas of granite and metamorphic rocks, the pH levels of rivers have decreased at an apparent average rate of 0.017 pH units/year. Concomitant with the decrease in pH has been a decrease in HCO_3^- and increases in Al^{+++} and $SO_4^=$ concentrations. Metamorphic rocks in the sensitive region are of the Meguma Series which has two primary divisions: the Goldenville Formation primarily consisting of greywacke, and the Halifax Formation primarily consisting of slates. When the rivers in this study are divided according to the predominant geology of their bedrock, the Ingram and Gold rivers are seen to lie on granite and the Mushamush and Petite on slate. Slates are weathered readily and the surfaces of slate areas have been planed off by glacial action. The resultant loose material was carried away to form a deep glacial drift which contains a high percentage of silt and clay (Roland 1982). Sometimes the weathered material has been shaped into oval mounds called drumlins, which are particularly prevalent in Lunenburg County. Clay has a high ion-exchange capacity and can buffer against acid inputs as does other imported soil in the drumlins which may have originated from sandstone areas to the north of Lunenburg County. The presence of drumlins in this county account for the higher pH and alkalinity measurements recorded for the Petite, Mushamush and Gold rivers in comparison to measurements for the Ingram River, which lies on granite in an area of Halifax County relatively devoid of drumlins.

Angling catch during the 1955-59 period for the Gold, Petite and Ingram rivers is seen to be proportional to the drainage area of these rivers (Fig. 6). This earlier time period was chosen for comparison because, beginning in the 1960s, angling catch appears to have declined on the Ingram, probably because of the decreasing pH of the river. Thus, angling catch was higher in the Gold River which has the larger drainage area and lower in the Petite and Ingram rivers which have smaller drainage areas, similar to that of the Mushamush River. The total numbers of salmon angled during 5-year intervals from 1955 to 1979 for the Gold, Petite and Ingram rivers show a similar relationship with drainage area (Figs. 6 and 7). However, it is also apparent that angling catch/5-year interval during 1955-79 has increased in the Gold, decreased in the Ingram and remained relatively constant in the Petite Rivière.

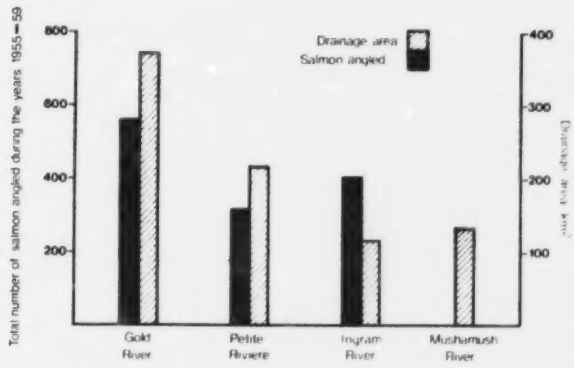

FIG. 6. Relationship between drainage area and angling catch during the years 1955-59 for the Gold, Petite, Ingram and Mushamush rivers.

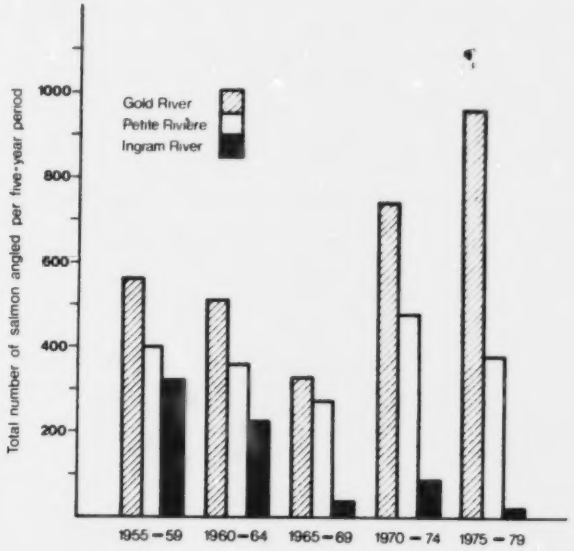

FIG. 7. Numbers of salmon angled per 5-year period on the study rivers during the 1955-79 interval.

The mean pH of the Ingram River during 1980 and 1981 was 5.0 (Watt et al. 1983), suggesting that partial recruitment failure may be occurring among the salmon population of that river (Farmer et al. 1980), a factor which explains the decline in angling catch. Angling effort in the Ingram River, expressed in rod days/5-year interval (Table 2), shows a steady decline from the 1955-59 period to the 1975-79 period which may be partially attributable to the declining salmon population in this river. Declining angling effort in the Ingram River has been accompanied by increased effort in both the Petite and Gold rivers. Catch/5-year interval has increased in the Gold River in response to increased effort but has remained relatively constant in the Petite Rivière; this suggests a population decline in the

TABLE 2. Angler effort on the Gold, Ingram and Petite rivers, 1955-79.

River	Rod-days per five-year interval				
	1955-59	1960-64	1965-69	1970-74	1975-79
Gold	2,086	3,088	2,590	1,798	4,596
Ingram	6,470	4,244	1,252	742	443
Petite	1,811	2,214	1,682	2,933	3,651

latter river. The increased effort in the Petite and Gold rivers in recent years may partially reflect the declines in the salmon populations of the Ingram River and other south shore rivers such as the East, Middle and Martins (Watt et al. 1983), which have occurred because of increased acidity.

Preliminary estimates of the potential rearing area in the Mushamush system indicate that the area from Little Mushamush Lake to the head of tide may contain 1,344 rearing units, each of 100 m^2, that Blockhouse Mill Brook contains 110 units, and the area above Little Mushamush Lake contains about 240 units. Assuming that only 75% of the potential rearing area can be classified as good to fair habitat then there exists 1,694 x 0.75 = 1,270 rearing units of that classification in the system. In accordance with Elson's (1957) estimate of 17 underyearling salmon per unit for low density stocking, the Mushamush system requires the release of about 17 x 1,270 = 21,590 hatchery-produced underyearling salmon. If survival to the 2-year smolt stage equals 15% (Elson 1957) and smolt-to-adult survival equals 15% (Doubleday et al. 1979), then the total production for the river would be 21,590 x 0.0225 = 486 adults. This should be considered a conservative estimate, as the area of the five lakes (2,000 hectares) on the system was not included in the calculation of rearing habitat. In this regard, experiments in Lake Storevatnet in southwest Norway indicate that 6.8% of the fin-clipped fingerling salmon which were released survived to the smolt stage (Hansen and Senstad 1982). Models describing the apportionment of adult salmon to the various fisheries for hatchery-produced smolts indicate that in Nova Scotia angling catch may equal 10% of total production (Parmer et al. 1981). Thus, the Mushamush system may be expected to yield a minimum of 50 adults per year to a sport fishery, if sufficient angler effort develops.

Some chemical characteristics of selected sites (Fig. 3) on the Mushamush River system were measured during March and again during September of 1982 (Table 3). Between the March and September sampling dates, measurements of pH, alkalinity and hardness showed small increases, which can be related to the greatly different flow rates which occurred on these dates. The chemical characteristics indicate that the only site which may be unsuitable for Atlantic salmon is Lantz Brook (Site 2) (Fig. 3), which had a pH of only 4.88 and no detectable alkalinity during March. The higher color of the brook suggests there are natural inputs of humic materials which may lower pH. In addition, a sawmill which continues to operate on this brook may be causing some deterioration in water quality. The pH (5.4-6.5) and alkalinity (0.7-6.4 mg/L) ranges of all other sites indicate that they are suitable for salmon enhancement purposes. Excepting Lantz Brook, pH, alkalinity and hardness were lowest in North Brook (Site 5) which receives flow from West and Whale lakes. There are few drumlins surrounding these lakes, which are located in an area of granite rather than of slate as occurs in the rest of the Mushamush system. This accounts for the lower pH which was observed for North Brook.

A qualitative electrofishing survey was carried out on 16 Jul, 1982, to determine if the Mushamush system was supporting a population of naturally produced juvenile salmon. Six areas of the river (Fig. 3) received electrofishing effort for periods of 10-30 minutes each and the numbers of Atlantic salmon captured were:

Site	Numbers of parr	
	Underyearling	Postyearling
1	0	7
2	2	2
3	0	0
4	0	0
5	3	0
6	5	1

The results indicate that the areas both above and below Little Mushamush Lake have been recolonized by a small population of Atlantic salmon. These may represent native progeny which inhabited the lower areas of the system, or the progeny of adults which have strayed from other south-shore rivers. Other species observed during the electrofishing surveys and during MacEachern's (1955) study include American eel (Anguilla rostrata), banded killifish (Fundulus diaphanus), brook trout (Salvelinus fontinalis) and white sucker (Catostomus commersoni). Freshwater clams

TABLE 3. Some chemical characteristics of selected sites on the Mushamush River system during 1982. (Site numbers correspond to those shown in Fig. 3.)

Site	Date	pH	Total alkalinity (mg/L)	Total hardness (mg/L)	Specific conductance (μmho/cm)	Apparent color (rel. units)
1	Mar 24	5.99	1.7	5.6	31.0	20
1	Sep 21[1]	6.50	3.8	8.4	35.1	15
2	Mar 24	4.88	0.5	3.0	26.4	55
2	Sep 21	6.10	1.8	6.4	37.9	75
3	Mar 24	5.98	2.1	7.2	32.6	30
3	Sep 21	6.40	6.4	12.9	51.8	25
4	Mar 24	5.90	1.3	5.5	29.4	15
4	Sep 21	6.11	1.8	6.1	28.6	10
5	Mar 24	5.40	0.7	4.0	23.6	25
5	Sep 21	5.95	0.8	4.4	22.2	10
6	Mar 24	6.20	2.1	6.4	31.1	10
6	Sep 21	6.00	4.1	7.5	36.9	15
7	Mar 24	6.20	1.9	5.5	32.0	10
7	Sep 21	6.21	2.2	6.2	30.8	10
8	Mar 24	6.31	2.4	6.7	30.9	10
8	Sep 21	6.30	3.9	8.3	33.0	15

[1]Analysis for other chemical characteristics were conducted at this site and the results are: sulfate, 3.8 mg/L; chloride, 5.2 mg/L; aluminum, 0.006 mg/L; calcium, 2.1 mg/L and magnesium, 0.8 mg/L.

(*Anodonta* sp.) were also observed in the river. This is of interest because clams are not able to survive in many other south-shore rivers because of the low pH and calcium ion concentration of these rivers. Experimental netting during 1981 in the headwater lakes indicates that the system also has a population of white perch (*Morone americana*), gaspereau (*Alosa pseudoharengus*), golden shiner (*Notemigonus crysoleucas*), yellow perch (*Perca flavescens*) and brown bullhead (*Ictalurus nebulosus*) (Nova Scotia Dept. of Lands and Forests survey, unpublished).

Several rivers which empty on the Atlantic side of mainland Nova Scotia are no longer able to support Atlantic salmon populations because of their increased acidity (Farmer et al. 1980; Watt et al. 1983). Angler effort has increased on some of the remaining rivers to the extent that the quality of the angling experience has declined. Factors which indicate that the Mushamush system is suitable for an enhancement effort through the introduction of hatchery-produced salmon include: its favorable chemical characteristics, the recent removal of barriers to salmon migration, the present low density of naturally produced salmon and the high angling effort which exists on nearby rivers such as the Gold, Petite and LaHave. Interest in the recolonization of the Ingram River has been expressed by the Fisheries Operations Branch; however, its unfavourable chemical characteristics indicate that the system may be suitable only for a put-and-take angling fishery, utilizing adults returning from the release of hatchery-produced smolts. While angling effort has substantially increased on the Petite Rivière, the relatively constant catch suggests maintenance stocking of hatchery salmon may be required. Water chemistry of this system remains suitable for salmonid reproduction as does the chemistry of the Gold River, where catch has increased in response to increased effort. Further studies are required before attempts at enhancing this latter system are undertaken through the use of hatchery-produced salmon.

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POOR

QUALITY

ORIGINAL